WCB

Abstracts should be submitted on-line at wcb2014.com between November 15, 2013 and January 15, 2014 and be no more than 400 words + 1 key reference, if no figures, or no more than 350 words + 1 key reference + 1 figure (<250 kB).

Particle-Based Models For Cell Mechanics And Mechanobiology: Applications To Cell Spreading, Growth And Migration

Hans Van Oosterwyck1,3, Tim Odenthal1,2 Bart Smeets1,2,3, Tommy Heck1, Herman Ramon2.

1 Biomechanics Section, KU Leuven, Leuven, Belgium; 2 MeBioS, KU Leuven, Leuven, Belgium; 3 Prometheus, div. Skeletal Tissue Engineering, KU Leuven, Leuven, Belgium.

Introduction

The mechanical environment is an important determinant of cell fate, through the conversion of mechanical signals into a biochemical response in a process called mechanotransduction. Unraveling mechanotransduction mechanisms implies among others that cell mechanical forces need to be quantified, for which experimental and computational methods should be applied in a complementary way. We have established a powerful particle-based computational framework that can quantify cell mechanical forces at intercellular and subcellular scale.

Results and Discussion

The framework is able to calculate the mechanical behavior of single cells as well as multicellular systems, by describing entities as mechanically interacting particles. Depending on the application and considered length scale, a particle can represent the mechanical and geometrical properties of a single cell or a subcellular component (such as part of the membrane or cytoskeleton). Particle movement is governed and calculated by solving a momentum balance. A crucial step is the formulation of equations that capture interacting forces, such as forces due to cell-cell contact, friction, cell division, as well as forces (or equivalent potentials) that govern the deformation of subcellular components.

Within this framework we have developed a novel deformable cell mechanical model that is able to capture the spreading dynamics of red blood cells [1]. The model is able to identify the mechanisms that govern this dynamics: while the initial spreading rate was found to be related to energy dissipation upon contact establishment (friction) between the cell and the substrate, the decrease of spreading rate observed in a later phase could be attributed to an increase in tension and viscous dissipation in the cell's cortex as the cell continues to spread. Next, this deformable cell mechanical model was incorporated into a model of a multicellular and growing (dividing) aggregate. We found that during cell growth a strong increase of magnitude and heterogeneity of intercellular forces around the time of confluency can be expected. This is accompanied by an equally strong increase of cell membrane tension (figure 1) and normal pressure (with local values up to 100 Pa). Active cell mechanical components are currently being added, as required for studying cell migration.

References: [1] T. Odenthal, B. Smeets, P. Van Liedekerke et al. Analysis of Initial Cell Spreading Using Mechanistic Contact Formulations for a Deformable Cell Model (2013) PLoS Comput Biol, 9(10): e1003267

Acknowledgement: The research leading to these results has received funding from the European Research Council under the European Union's Seventh Framework Programme (FP7/2007-2013)/ ERC Grant Agreement n° 308223). We also acknowledge the Agency for Innovation by Science and Technology in Flanders (IWT; PhD fellowship of BS) and Research Foundation Flanders (FWO-Vlaanderen; PhD fellowship of TH, grant G.0821.13) for financial support.

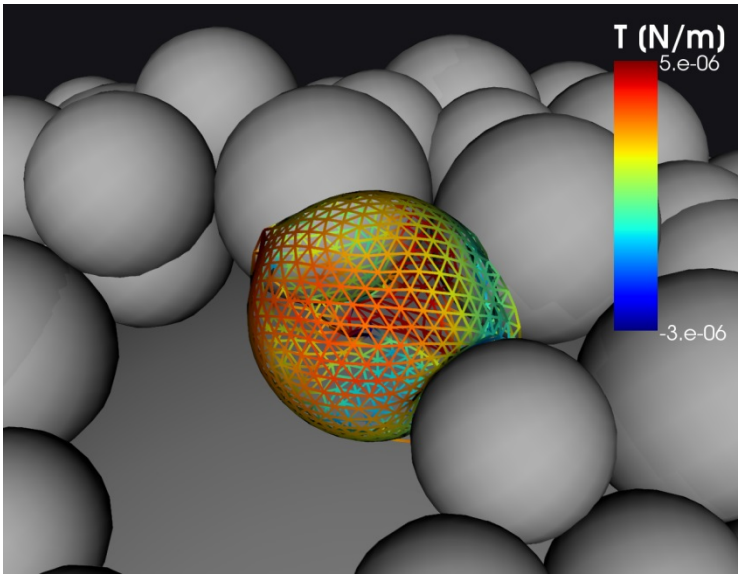

Figure 1: Cell membrane tension, as calculated by means of a deformable cell mechanical model, incorporated in a model of a multicellular aggregate (growing and dividing grey cells).